# ABSTRACT

In view of the ever increasing demand for land space all over the world because of rapid urbanisation, there is an increasing need to construct on weak and soft grounds, which were considered unsuitable for construction just a couple of decades ago In such situations, most economical solutions such as ground improvement techniques are always constantly looked for The reinforced earth is one among such techniques The reinforced earth is a coherent material of greater strength and stability formed out of granular material and the reinforcement The recent development in this field is the use of three-dimensional cellular mattresses in reinforcing weak soils Geocell reinforcement is a three dimensional, polymeric, honeycomb like structure of cells interconnected at joints The cell by virtue of its three dimensional nature offers an all round confinement to the encapsulated soil and the filled cells being connected together, the panel acts like a large mat that spreads the applied load over an extended area, instead of directly at the point of contact, leading to an improvement in the overall performance This concept has been adopted for earth retaining structures and embankments In the literature the adoptability of this technique for weak foundation beds was not been given much attention

In this investigation, to study and understand the behaviour of geocell reinforced foundation systems subjected to monotonic loading conditions, a total of 250 model tests were carried out on different foundation soils (viz sand, clay and sand overlying soft clay) reinforced with and without geocell mattress under circular footings The detailed program of experiments conducted on each foundation bed is described The parameters studied in this investigation are the placement density of the sandy soils (ID), size of the footing (D), depth of placement of the geocell mattress from the base of the footing (u), geometry of the geocell mattress (b and h), base layer placed below the geocell mattress, embedment depth and width of footing ($D_f$ and D) All these parameters are expressed in non-dimensional form, normalized with the footing width and the results are presented in the form of non-dimensional charts For comparison of results and to evaluate the efficacy of the geocell mattress, non-dimensional parameters are introduced viz Improvement factors ($I_f$) and Percentage reduction in

footing settlements (PRS) The results obtained from the laboratory scale geocell reinforced foundation systems are then simulated numerically using Fast Lagrangian Analysis of Continua in 3D (*FLAC*3D)

It has been deduced from the test results that there is a critical depth of placement of geocell mattress to get optimum benefit out of the reinforcement The critical geometry of the geocell mattress is found to be b/D = 4 9 and h/D = 1 8 which assured a bearing capacity improvement factor of about 6 fold against unreinforced bed It has been ascertained beneficial to have a dense infill material in the geocell pockets to get better benefit out of the reinforcement The influence of footing width on the performance of geocell reinforced foundation system is significant as long as the footing width is larger than that of the geocell pocket opening size Further increase in footing performance is observed with the footing embedment depth and introduction of an additional base layer placed below the geocell mattress As high as 9 5 fold increase in bearing capacity is observed in case of footing embedded at a depth of 0 6D It is also observed that the influence of additional base layer reduces with the increase in height of geocell mattress It has been observed that the contribution of stiffer bodkin members in load carrying capacity is significant The results also infer that up to 85% reduction in footing settlements can be achieved if the sand bed is reinforced with geocell mattress of its optimum geometry along with a geogrid layer placed at its base Results of test carried out on planar reinforcement highlighted that the geocell reinforcement is more effective than the planar reinforcement in increasing the bearing capacity and reducing footing settlements It has been shown with the results of pressure gauges that the footing pressure is distributed over an extended area of the subsoil if the foundation soil is reinforced with geocell mattress The strain measurements in the geocell walls impart that the central core material of the geocell mattress is directly participating in the load carrying mechanism and distributing the same over wider area of sub soil The reinforcement away from the loading region is contributing as a secondary reinforcement providing anchorage to the central core reinforcement

An attempt has been made to improve the bearing capacity of a soft soil reinforced with geocell mattress filled with the same foundation soil through seven series of model tests It has been observed the soft soils can be used as infill material for geocell reinforcement The test results convey that the optimum geometry of geocell

mattress is same as that of the size of geocell mattress obtained in case of sand beds It is also noticed that the maximum benefit can be achieved if the geocell mattress is placed just below the footing with a film of sand layer of about 2 mm thick From practical stand point, it is recommended that a small layer of free draining material should be placed between the footing base and the geocell mattress to avoid the direct contact of footing with the geocell mattress and to accelerate the consolidation process of the underlying soft clay The performance of the bed further improved with the inclusion of base geogrid layer and its influence reduced with increase in height of geocell mattress The performance of the footing is increased with increase in footing embedment depth Over five fold increase in bearing capacity is observed with geocell reinforcement against unreinforced clay bed As high as 95% reduction in footing settlements is noticed, when the soft soil is reinforced with the optimum size of geocell mattress along with a base geogrid layer

The results of model tests conducted on geocell reinforced sand overlying soft clay beds are also presented It has been observed that the load carrying capacity of the bed is continuously increased with the increased thickness of unreinforced dense (ID=70%) sand blanket over the soft soil It further increase with the inclusion of reinforcement in term of geocell mattress till the width ratio (b/D) is reached 5 and height ratio (h/D) is reached about 2 It could also be said from the results that the undrained shear strength of the underlying clay is independent of the bearing capacity improvement factors It is also noticed that the use of stiffer geogrid material improves the performance of the entire system In total a 44 fold increase in bearing capacity of the footing has been obtained by providing geocell reinforcement of adequate dimensions along with a layer of planar geogrid at its base in the sand layer overlying the soft clay bed compared to the bearing capacity of the clay bed alone (H/D = 0)

An attempt has been made to simulate numerically the laboratory scale geocell reinforced foundation systems Fast Lagrangian Analysis of Continua in 3D (*FLAC*3D) is used to simulate the geocell mattress in different foundation soils under circular loading The behaviour of steel circular plate (footing) is assumed as elastic The elastic-perfectly plastic Mohr-Coulomb model is used for studying the behaviour of soil The geocell is modeled using the structural elements, geogrids, which considers the interface properties of the soil and the geogrid The geogrid material

constitutive behaviour is considered as isotropic elastic A good agreement between the experimental and numerical results has been noticed in case of unreinforced foundation beds It has been observed that the model has relatively over predicted the values at higher footing settlement range (s/D ≥ 15 to 20%) for different foundation beds considered The numerical results depicts that the model should be further refined by incorporating the appropriate constitutive model for clays for better results The numerical results of geocell reinforced foundation systems closely match with the experimental results and the model can be extended to real full scale field tests and prototype structures to predict the real behaviour of the same

The voids can occur under structures at greater frequency in areas having soluble rock formations such as limestone and dolomite and also in areas having active mining operations To understand the behaviour of footings resting on clay beds with void, model load tests have been conducted to evaluate the potential benefits of providing geocell reinforced sand mattress over clay bed with a continuous circular void The test results clearly demonstrate that geocell mattress can substantially increase the bearing capacity and reduce settlement of the clay sub grade with void A 40 fold increase in bearing capacity could be obtained by providing geocell reinforced sand mattress of thickness (H) 3 65D with basal geogrid layer, over the soft clay sub grade with void In order to have beneficial effect, the geocell mattress must spread beyond the void at least a distance equal to the diameter of the void The optimum width of the geocell mattress is found to be around 5 (b/D = 4 9) The influence of void over the performance of the footing reduces for height of geocell mattress greater than 1 8 times the diameter of the footing It is also concluded that the overall bearing capacity of the foundation bed increases with increase in density of the fill soil